METHOD AND APPARATUS FOR PROVIDING A SYNCHRONOUS COMMUNICATION ENVIRONMENT

FIELD OF THE INVENTION

This invention is related to radio frequency (RF) communication systems, and more particularly to a method and apparatus for providing a synchronous communication environment.

BACKGROUND OF THE INVENTION

In wireless communication systems, effort has been made to increase the use of spectrum to allow for a greater number of users of a given frequency band. One example of a technique to increase spectrum efficiency is a frequency division multiple access (FDMA) technique. In a conventional FDMA system, a given frequency band is divided into a number of channels, wherein each channel is occupied by one user. An FDMA system can also be a time division duplex (TDD) system wherein a given RF channel is used for both forward and reverse directions of communication which are separated in time.

Other techniques comprise digital multiple access communication systems. One such conventional digital multiple access technique for increasing efficiency of the use of spectrum is a time division multiple access (TDMA) technique. In a TDMA system, each channel for the transmission of signals is divided into a plurality of slots. Each time slot may be allocated to a different call. A TDMA system can also employ TDD techniques. Accordingly, a number of calls can be simultaneously transmitted on a single channel or frequency.

Finally, increased spectrum efficiency can be achieved by spread spectrum techniques, in the form of either a slow frequency hopper system or a direct-sequence CDMA system. In a slow frequency hopper system, the carrier frequency of the signal is changed at a predetermined rate over a wide range of possible frequencies in a pseudo-random sequence known in advance by the receiver. Generally, spread spectrum techniques reduce the effects of both intentional or unintentional interference. Direct sequence CDMA systems allow multiple users to share the same spectrum wherein each user is assigned a unique psuedonoise code sequence. The signal is spread by the wide bandwidth pseudo-noise sequence known in advance by the receiver.

In digital multiple access communicationsystems having multiple base stations, there must be some coordination among the base stations to ensure that the base stations are properly synchronized. Synchronizing the base stations can be accomplished if the base stations are a part of a common system and are physically connected. However, base stations which are not physically connected must be synchronized if they are part of a common system. Further, if the base stations operate independently on common frequencies, the base stations must communicate to be properly synchronized. Accordingly, there is a need for a method and apparatus for synchronizing base stations operating in a digital multiple access communication system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of a wireless communication system having multiple base stations coupled to the public system telephone network.

FIG. **2** is a block diagram of circuitry for a conventional wireless base station or handset.

FIG. **3** is a flow diagram showing the preferred steps for determining master and slave designations for base station and chain building in the wireless communication system of FIG. **1**.

FIG. **4** is a flow diagram for showing the preferred steps for determining an available index in a slow frequency hopper system.

FIG. **5** is a network topological diagram showing the coordination of overlapping base stations in a wireless communication systems.

FIG. **6** is a flow chart showing the general steps for the coordination of base stations during chain reversal as shown in FIG. **5**.

FIG. **7** is a first embodiment of an air interface protocol having multiple sync slots for coordinating base stations.

FIG. **8** is a detailed flow diagram showing the coordination of base stations having the air interface protocol shown in FIG. **7**.

FIG. **9** is a second embodiment of an air interface protocol having a single sync slot and a blank slot for coordinating base stations and handsets.

FIG. **10** is a detailed flow diagram showing the coordination of base stations having the air interface protocol shown in FIG. **9**.

FIG. **11** is a flow diagram showing digital phase lock loop operation for a base with a synchronization source.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In a digital multiple access communication system, each base station operating within range of another base station must be synchronized to prevent interference. The present invention provides synchronous communication in a communication environment wherein multiple base stations are adapted to operate on the same frequencies. In particular, the base stations such as residential base stations must be coordinated to minimize interference with other base stations which otherwise operate independently. According to the present invention, each base station operating in a system will determine whether another base station operating on the same frequencies is within range. One of the base stations will assume a role as a master and the remaining base station will then synchronize to the master base station. Preferred methods for synchronizing the base stations, including signaling protocols, synchronization chain building and collision avoidance techniques for building synchronization chains, are also disclosed.

Turning first to FIG. **1**, a wireless communication system **102** is shown. The wireless communication system has a plurality of base stations **104**, each of which provide RF coverage over an area **108**. Each base station may be coupled to a public system telephone network **106**. However, it will be understood that the circuit and method of the present invention could be implemented in a wireless communication system having base stations which are not coupled to a public system telephone network. The base stations could be coupled together in an independent network, or could be stand alone units which happen to operating in the same frequency bands. Each base station is also adapted to communicate with one or more handsets **110**. Finally, each base station can communicate with another base station which is within range by way of RF signals.

Turning now to FIG. **2**, a block diagram shows a conventional base or handset circuit. In the preferred embodiment, an ASIC (Application Specific Integrated